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100 Meter Time of Flight System for Transmission Experiments

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INTRODUCTION

A detector system has been designed and constructed for neutron time of flight measurements at the Gaerttner Laboratory at Rensselaer Polytechnic Institute [1]. The system was designed to make use of the capabilities of the linear electron accelerator housed at the facility in measuring neutron spectra in the energy range of 0.2 to 20 MeV. The system is required to have a fast response time in order to obtain highly detailed total cross section data in this energy region. The detector system and electronics are explained as well as some preliminary results.

DESCRIPTION OF SYSTEM

Detector

The detector is a modular system consisting of 6 individual EJ-301 proton recoil scintillation detectors. Each module is an aluminum container with a 35.5 cm by 18 cm face and a depth of 13.8 cm with two evenly spaced, rear mounted, photomultiplier tubes to collect the emitted light. Two photomultipliers per module give the ability to either increase the sensitivity of the module in collecting low level signals or filter after pulsing effects that can occur within the photomultiplier tube. The filtering takes place by using a logical AND on the two tubes, assuming that a true pulse within the detector will be collected by both photomultiplier tubes. The layout of the detectors was chosen to take advantage of the neutron beam geometry at the detector location, 100 meters from the neutron source.

The advantages of a modular design include:

1. An individual unit may be removed for maintenance
2. The layout of the system may be altered for different beam geometries
3. Logic units may be used to reduce high energy background signals by employing coincidence
4. More modules may be added without redesigning the entire system

Electronics

The electronics system is designed around the neutron time of flight method in which a clock is started when the linear accelerator is fired and a stop signal is generated from the neutron detector. The electronics for the stop signal are located in the 100m flight station alongside the detector. They consist of a computer controlled high voltage power supply (HVPS), a constant fraction discriminator for each of the twelve photomultiplier tubes, arithmetic logic units, and a majority logic unit. The HVPS supplies regulated power to the photomultiplier tubes allowing the ability to easily control the tube voltage. The output from each of the photomultiplier tubes is fed to a constant fraction discriminator which provides for optimum time resolution over a wide range of pulse amplitudes, providing a fast Nuclear Instrument Module (NIM) signal for each input pulse. This output is then fed into the arithmetic logic units (ALU). The ALUs analyze the combined signals from common photomultiplier tubes on a single detector module and pass only signals in which both tubes indicate a signal. This eliminates the after pulsing that can occur from having the photomultiplier tubes located in the neutron beam. The output is then fed into the majority logic unit that collects the signals and outputs the stop signal. This setup allows us to choose the exact number or range of detectors required to provide the stop signal for the time of flight clock. This is beneficial for removing high energy background such as cosmic ray radiation, which would cause several detectors to fire simultaneously.

All components in the system provide outputs of fast NIM signals enabling us to minimize the dead time of the system.

RESULTS

Data were taken using a 33 cm thick carbon sample to test the detector system and validate the setup. The transmission measurement used consisted of comparing data taken with the carbon sample in the well collimated neutron beam and the open beam without the carbon sample. The transmission is then the ratio of the count rate measured with the sample in the beam and the sample out of the beam. Data were recorded and analyzed in the range of 1 to 15 MeV, shown in figure 1. The results show a good agreement with calculated results using the relationship between transmission and the material cross section given by

$$Transmission = e^{-N\sigma_t(E)} \tag{1}$$

where N is the sample material number density and $\sigma_t(E)$ is the total microscopic cross section of the sample at energy E, taken from ENDF/B-VI.8[2].

With the recent improvements to the electron gun at the Gaerttner Labs giving the ability to yield neutron pulses on the order of 5 nanoseconds, this system will provide high quality, high resolution transmission data for total cross section analysis and spectrum measurements.

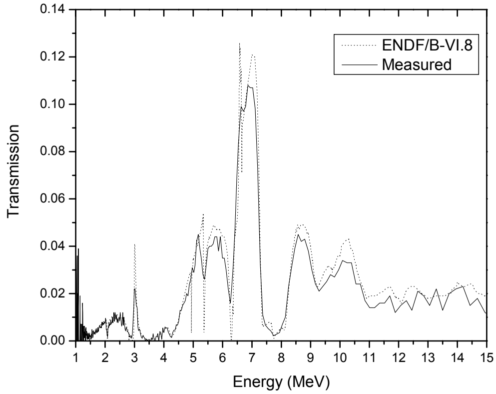

Fig. 1. Measured transmission data compared to data calculated from ENDF/B-VI.8.

REFERENCES

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2. U.S. Evaluated Nuclear Data File ENDF/B-VI.8 (CSEWG, October 2001), www.nndc.bnl.gov/csewg.